[Continued on next page]

(54) Title: METHOD AND SYSTEM FOR MANAGING DATA FLOW BETWEEN MOBILE NODES, ACCESS ROUTERS AND PEER NODES



"FLAT" LOCALIZED MOBILITY WITH FAST HANDOVERS
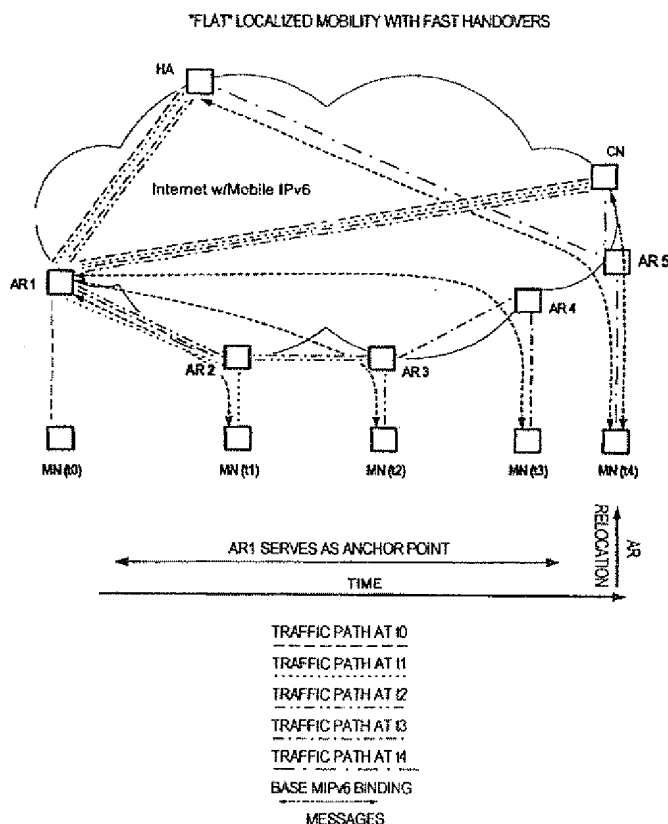
(57) Abstract: The invention relates to a method and
system for managing data flow between Mobile Nodes
(MNs), Access Routers (AR) and peer nodes (HA,
CNs), wherein, when a Mobile Node makes handover
from one Access Router (AR) to new Access Router
(AR2, AR3, ... ARn), a decision is made whether to
command the first Access Router (AR1) to act as
an Anchor Access Router and forward data from the
peer nodes (HA, CNs) to the Mobile Node via the
new Access Router (AR2, AR3, ... ARn), or to send
an update of the new position of the mobile node to a
peer node (HA, CN). The decision is made based on at
least one of the following criterias: -the number of peer
nodes (HA,CN1, CN2, ... CNn) to which it has ongoing
sessions, -the time elapsed from a previous update
sent to the peer nodes (HA, CNs), -the traffic activity
between the peer node(s) (HA, CN1, CN2, ... CNn) and
the Mobile Node (MN), -amount of signaling or traffic
load between mobile node and Access Router and/or
peer nodes, -the state of the underlying layers, -the
state of the mobile node, -the frequency of handovers.

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## METHOD AND SYSTEM FOR MANAGING DATA FLOW BETWEEN MOBILE NODES, ACCESS ROUTERS AND PEER NODES

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### DESCRIPTION

### FIELD AND BACKGROUND OF THE INVENTION

10   The invention generally relates to Mobile IP (Internet
     Protocol), and in particular to a mechanism for overcoming
     problems associated with Mobile IP under frequent change of
     care-of address by the Mobile Node (MN).

15   Mobile IP is a technology which allows a Mobile Node (MN)
     like portable computer, cellular phone or personal digital
     assistants to travel while still retaining its Internet
     Protocol (IP) address. When the Mobile Node is located in
     foreign networks the Correspondent Node (CN) gets the current
20 · address (CoA) from Home Agent (HA). The Correspondent Node is
     any node (another Mobile Node, fixed Internet node or some
     network element) that sends or receives a packet to/from the
     Mobile Node.

25   Because Mobile IPv6 (MIPv6) is the up-to-date version of the
     Mobile IP, it is used to describe the invention. Notice that
     instead of the Mobile IPv6 the Mobile IPv4 can be used as
     well.

30   MIPv6 is designed over an end-to-end signaling paradigm,
     where only the Home Agent (HA) and Correspondent Nodes (CNs)
     adjust to the layer 3 (L3) movement of a Mobile Node (MN).
     Due to this, Mobile IPv6 faces various overheads if the
     movement of the MN occurs too frequently. In the case of
· 35   frequent handovers amongst wireless transceivers covering

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small geographical areas, link-layer mechanisms for link maintenance (i.e. link-layer handoff) might offer faster convergence and fewer overheads than Mobile IP.

5    Given the current trend of pushing IP closer to the wireless interface in order to deploy a full IP infrastructure, several solutions to this problem are being studied based on IP protocols. A brief overview of these draft proposals is given below.

10

The Mobile IPv6 protocol relies on binding messages (binding updates, binding acknowledgements, and binding requests) sent between the MN and the HA and CN. This allows to maintain reachability of MNs while they move from subnet to subnet and

15   thus change care-of address (to one whose prefix is advertised in that particular subnet). Binding Updates (BUs) are used to inform HAs and CN of the MN's current address. BUs cause signalling overhead in the radio interface and processing overhead at the home agent and at the

20   corresponding node.

Local Mobility Management (LMM) protocols are designed for environments where mobile hosts change their point of attachment to the network (and thus change care-of address)

25   so frequently that the following undesired effects would occur in a network running only on base Mobile IPv6: signaling overhead, network signaling overhead, processing overhead at the peer nodes, signaling overhead over the air, signaling delay, and packet loss.

30

With regard to signaling overhead (network signaling overhead, signaling overhead over the air and processing overhead at peer nodes), the network signaling overhead can be minimized in most of the cases by synchronizing binding

35   messages to higher layer payloads (i.e. piggybacking IP

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signaling to existing payload).

Signaling overhead is also exhibited at the air interface due
to multiple BUs (Binding Update messages) across the air
5   interface when there are several outstanding sessions with
CNs. In order to avoid triangular routing, Mobile IPv6 MNs
should send BUs to each of these CNs. Triangular routing is a
well known problem which occurs while the MN is located far
away from its home network and is communicating with CN
10  located near the foreign site. Each datagram sent from the CN
to the MN travels to HA which then forwards the packet to the
MN. Thus the packets are traveling long way instead of the
shortest path.

15  Processing overhead at peer nodes can occur at the Home Agent
or at the Correspondent Nodes particularly if the
correspondent node is serving a large number of mobile nodes
(e.g. streaming server). Since the HA is specifically
introduced in the network to perform a mapping and tunneling
20  functionality which forms the basis of Mobile IPv6, the HA
should be designed to handle large amounts of signaling.
However, CNs might not be willing to dedicate much processing
overhead caused by mobility of MNs. It would thus be
desirable to make MN's mobility as transparent as possible to
25  CNs without posing potentially tough processing requirements
from them (and without reverting back to triangular routing).

Signaling delay may occur across long paths existing between
the mobile node and the home agent and any correspondent
30  nodes. In the base Mobile IPv6 the mobile node would need to
notify its Home Agent and any correspondent nodes with which
it has active bindings. With the introduction of a Localized
Mobility Management (LMM) protocol this delay is reduced.

35  The introduction of an LMM in any future architecture can be

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seen as an overhead especially if the protocol is complex.
The present solutions (Hierarchical Mobile IPv6 (HMIPv6) ,
Mobile IPv6 Regional Registrations (MIPv6RR)) complicate the
Mobile IPv6 operation in the following manners:

5       - introducing the need of extensions to advertisements,
        - introducing new or modified binding messages,
        -     additional node functionality (Gateway Mobility Agent
        (GMA) / Mobility Anchor Point (MAP), etc),
        - need for configurations (some of which are manual
10      configurations, e.g. In MIPv6RR each regional-aware router
        needs to be manually configured with the IP address of the
        immediate descendant routers)
        - need for security associations amongst those nodes,
        - increased functionality in the mobile node etc…..
15

There have also been increasing concerns regarding the size
of binding caches inside GMA/MAP (which can be seen mimic the
function of the SGSN in GPRS). This also introduces single
point of failures in the hierarchy, which is of course
20      undesirable. If a hierarchical agent goes down, the entire
edge network is compromised. While this problem can be
addressed by replication mechanisms, these mechanisms
introduce additional complexity.

25      The hierarchical-LMMs tend to require even more signaling
over the air in terms of:
        - extensions to router advertisements (additional 28 bytes
        for each MAP in the case of HMIPv6, or an additional 24 bytes
        for each advertised Regional care-of address in MIPv6RR);
30      - extensions to binding updates in order to perform a
        regional binding update operation (20 bytes for the previous
        access router sub-option in MIPv6RR. This is needed in order
        to determine which router is the crossover router);
        - tunneling overhead (an additional 40 bytes for the
35      tunneling IPv6 header for each data packet sent over the air

in HMIPv6. Tunneling overhead is overcome in MIPv6RR through the address swapping in the regional forwarding mechanism.).

5    It should be noted that schemes such as header compression do not overcome the first two overheads mentioned above. Every time a movement takes place, each context need to be re-constructed due to changing care-of address and at least one packet per session is uncompressed. There might be multiple compression sessions even per one CN (VoIP over RTP over UDP,
10   video over RTP over UDP are two different contexts). Transferring or re-starting many contexts also causes processing overhead. Experiments show the restart overhead can be of the order of 6 packets.

15   The air interface utilization can be reduced by both HMIPv6 and MIPv6RR associated as only one (regional) binding update needs to be sent to the MAP/GMA or crossover router, as compared to the base Mobile IP case in which multiple binding updates need to be sent - one to the Home Agent and one to
20   each correspondent node.

Localized Mobility Management limits signaling to short paths and hence reduces the probability of packet loss.

25   The signaling delay and packet loss problems can be coped with by the Fast Handovers protocol (or some similar mechanism).

In the light of the problems outlined above several solutions
30   based on different principles were proposed mainly within the MobileIP Work Group (WG) in IETF. Generally, LMMs (formerly known as micro-mobility protocols) try to overcome the above-mentioned overheads associated with the base Mobile IPv6 protocol when mobile nodes change their care-of address (CoA)
35   frequently. Current LMM draft proposals within IETF can be

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broadly classified as follows:

1) LMMs which are based on hierarchy as shown in Fig. 1.
These hierarchy-LMMs are based on extensions to Mobile IP,
5    and currently consist of "Hierarchical Mobile IPv6" (HMIPv6),
and "Mobile IPv6 Regional Registrations" (MIPv6RR). These
LMMs create a virtual slack in the fast movement of MNs as
seen by peer nodes outside the visited domain. This is
achieved by using two care-of address; one regional and one
10   local, of which only the latter changes at each change of AR.
The area in which a MN is allowed to keep the same regional
care-of address is based on extensions to Mobile IPv6 router
advertisements sent over the air which delimit domains in
which different Regional care-of address could be used.

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2) LMMs based on host routes. A typical example of this
class of LMMs is Cellular IP. These LMMs also allow for
Mobile IPv6 to act as the "macro-mobility" protocol, but they
are not based on extensions to Mobile IPv6. MN maintains the
20   same (topologically incorrect) IP address while moving across
ARs belonging to the same domain. Reachability of the MN is
maintained by creating host routes inside the domain. The
major drawback in these proposals is the scalability when
routing tables contain a large number of rapidly changing
25   host routes (routing table entries with /128 subnet mask).

3) LMMs based on tunneling across the edge of the
network. Currently, there are no proposals in IETF based on
this model. A mechanism creating forwarding paths between
30   MN's care-of addresses can improve handoff smothness in
Mobile IPv6.

Generally, Mobile IPv6 Regional Registrations introduce a
regional and a primary (on-link) CoA. The regional CoA is the
35   CoA as seen from outside the visited domain, and remains the

same while the MN remains within a visited domain (GMA). The
primary CoA allows to keep track of the MN's regional
movements, but its change is transparent beyond the Gateway
Mobility Agent (GMA).

5

Hierarchical Mobile IPv6 reduces mobility signalling with
external networks by employing a local hierarchical structure
based on the introduction of a new agent called Mobility
Anchor Point (MAP). This agent acts essentially as a local HA
10    for a MN it is serving. The domain boundaries of a MAP are
defined by the ARs advertising the MAP information to the
attached MNs. A MAP can have two different modes. In "Basic
mode" a MN forms a Regional-CoA (RCoA) on the MAP's subnet
and an on-link CoA (LCoA). The packet delivery to the MN is
15    achieved by interception and encapsulation at the MAP. In
"Extended mode" a MN may use a MAP's address as an alternate-
CoA. The packet delivery is achieved by decapsulation and re-
encapsulation of the packets at the MAP.

20    GMA (used in Mobile IPv6 Regional Registrations) and MAP
(used in Hierarchical Mobile IPv6) are nodes which contain
the mapping between the regional care-of address and local
care-of address, and take care of the tunneling or forwarding
between those addresses. MAP can be implemented by a router
25    in a visited network and GMA by software module in the
routers.

The base Mobile IPv6 uses the previous router notification
which binds the new care-of address with the previous care-of
30    address at the old Access Router as if the latter were a home
address. This causes encapsulation of traffic destined to the
old care-of address to the new care-of address as the outer
encapsulation destination address. This forwarding tunnel is
normally set up only after the MN arrives at the new link
35    (this mechanism is further optimized in Fast Handovers for

Mobile IPv6). However this does not solve the end-to-end
signaling overhead which was described in the previous
section, but merely solves the delay and packet loss problem
(i.e. the mobile user will be satisfied with the service but
5    the network operator will still be facing network overhead
due to frequent end-to-end signaling).

Cellular IPv6 and HAWAII propose mechanisms based on host
route (/128 bit netmask) entries inside routing tables. It
10   has been widely accepted that these proposals face severe
scalability problems due to the instability caused by a large
number of fast changing routing table entries. It should also
be noted that HAWAII is specific to Mobile IPv4.

15   In "Threshold-Based Registration (TBR) in Mobile IPv6" (L.
Yang et al., "Treshold-Based Registration in Mobile IPv6",
IFIP-TC/6 European Commission NETWORKING 2000 International
Workshop, MWCN 2000, Paris, France, May 2000), the MN
establishes forwarding paths from its immediate previous
20   care-of address. Only after a fixed number of immediate
forwarding steps, the MN establishes direct forwarding paths
from the primary care-of address (at the anchor home agent),
and only after a number of direct forwarding steps from its
primary care-of address the MN will register a new primary
25   care-of address at its HA. The aim of this mechanism is to
improve handoff smoothness in Mobile IPv6.

Independent of the local mobility mechanisms listed above,
Fast Handovers for Mobile IPv6 enables a mobile node to
30   configure a new care-of address before it moves to a new
access router, such that it can use this new care of address
immediately after connection with the new access router. Fast
Handovers additionally enables the setup of a temporary
forwarding path between the old access router and the new
35   access router. Thus, Fast Handovers may relieve the delay and

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associated packet loss problems described above. Fast Handovers is not aiming at overcoming the signaling overhead problem.

5    The mechanism presented by this invention augments the operation so that, among others, it solves or at least reduces the overhead problem.

10                    **SUMMARY OF THE INVENTION**

The present invention provides a method, system and device as defined in the independent claims or any one of the dependent claims.

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In accordance with one aspect of the invention, a method and system are provided for managing data flow between Mobile Node (MN), Access Routers (AR) and peer nodes (HA, CNs), wherein, when a Mobile Node makes handover from one Access

20   Router (AR) to new Access Router (AR2, AR3, … ARn), a decision is made whether the first Access Router (AR1) should act as an Anchor Access Router and forward data from the peer nodes (HA, CNs) to the Mobile Node via the new Access Router (AR2, AR3, …ARn), or to send an update of the new position of

25   the mobile node to a peer node (HA, CN). The decision is made based on at least one of the following criterias:
        -the number of peer nodes (HA, CN1, CN2, ... CNn) to which it has ongoing sessions,
        -the time elapsed from a previous update sent to the

30   peer nodes (HA, CNs),
        -the traffic activity between the peer node(s) (HA, CN1, CN2, …CNn) and the Mobile Node (MN),
        - traffic load or signaling load, between mobile node and Access Router and/or peer nodes,

35        -the state of the protocol layers 1 and 2,

-the state of the mobile node (the mobile may be in idle mode or in active state),
-the frequency of handovers.
The decision may be made by the Mobile Node, by the Network,
5    or by an entity in access network. The entity in the access network is preferably Access Router. Access Router functionality may be implemented for example in the Base Station or GPRS Support Node. The Access Router can be also a separate entity.
10

The maximum number of handovers for which the same Anchor Access Router is kept is preferably restricted to a pre-defined upper limit.

15   As example of these criterias mentioned above: The traffic activity between the node (CN1, CN2, …CNn) and the Mobile Node (MN) means that the decision is made in order to avoid unnecessary signaling or traffic between the MN and peer nodes. It can mean also that there is a cost function between
20   the signaling between peer nodes and access routers, and the signaling between different access routers.

Protocol Layers 1 and 2 means the protocol layers under IP Layer, for example air interface protocols (including radio
25   resource control) and physical layer. More generally, the layers may be any "underlying layers" which means not only "protocol layers 1 and 2" (fo example GSM/CDMA including radio resource control and physical layer). The "underlying layers" mean basically anything below IP layer. It can be
30   radio resource control protocol and L1 but if compared to GSM/WCDMA it can contain protocol such as SM, GMM, etc.

Examples of radio access network are CDMA or TDMA based radio access network technologies.
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The above functionality can be extended even after the MN has moved to ARn via two optional mechanisms, in the first of which a chain of tunnels between the Anchor Access Router and the current Access Router is created, and in the second

5     option a single tunnel between the Anchor Access Router and the current Access Router is created. The decision on whether to send BUs is always based on the criteria described above and on the number of times the CoA was changed without notifying the HA and CNs (in order to avoid excessively long

10    forwarding paths).

An Anchor Access Router (AAR) is the router responsible for the Mobile Node's (MN) Care-of Address (CoA) which is visible to the Home Agent (HA) and Correspondent Nodes (CN) while the

15    MN is attached to some other Access Router(AR) other than the AAR at radio layer (and at IP layer via a second CoA which is not visible to the HA and CNs). Remark that there may be provided many HAs as well as CNs that have ongoing sessions with MN.

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In more detail, when the Mobile Node has moved and selected a new Access Router as Anchor Access Router, a Binding Update message can always be sent to the previous Access Router, the decision on whether to send Binding Update messages being

25    always based on the criteria mentioned in claim 1, and/or on the number of times a Care-of-Address (CoA) was changed without notifying a peer node. Alternatively, when the Mobile Node has moved and selected a new Access Router as Anchor Access Router, a Binding Update message can always be sent to

30    the Anchor Access Router, the decision again being based on the criteria just mentioned.

The invention decreases the amount of Mobile IP related signaling between (potentially fast moving) Mobile Nodes

35    (MNs) and their peer agents (HA, CNs).

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In addition to the decreasing of signaling between Access
Routers and the Peer Nodes the invention in one aspect also
decreases the signaling in the air interface while the MN is
in idle state (because MN does not have to send the BUs over
5    the air, it is enough that the RRA (RAN Registration Area,
this is like UTRAN Registration Area) updates are sent).

In a typical radio access network, Registration Area (RRA) is
a set of access routers (and IP BTS if AR and IP BTS are
10   combined) which belong to same RRA. RRA is a L2 area concept
and is not seen to the IP level. Adjacent RRAs may overlap
with each other.

In accordance with one of preferred implementation of the
15   invention, a method and mechanism is provided for reducing
the number of binding updates sent by a fast moving MN to its
HA and CNs to a guaranteed maximum frequency. The processing
overhead at the HA and CNs, and the signaling overhead over
the air is thus minimized. A framework for a paging mechanism
20   for reducing signaling overhead caused by Mobile IP to keep
track of idle MNs is also presented. The signaling delay and
packet loss may also be reduced. The minimization of
signaling delay and packet loss may also be left to the Fast
Handovers for Mobile IPv6 mechanism as e.g. specified in the
25   respective Internet Draft of IETF (Internet Engineering Task
Force).

The invention introduces a method and mechanism based on
Access Router (AR) anchoring built on augmentations to the
30   Fast Handovers mechanism. Different heuristics are presented
on which the Anchor Access Router (AAR) could be relocated.
Two options are described which can be used to avoid multiple
levels of re-encapsulation which could possibly be caused by
multiple forwarding.
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In accordance with a further aspect of the invention, an
associated method and mechanism is provided to support paging
when a MN is in idle mode, thus limiting unnecessary network
overhead used for tracking idle MNs and also increasing the
5    MN's battery lifetime.

Since the method and mechanism according to preferred
implementation of the invention functions at the IP layer, it
is also suitable for localized mobility management across
10   homogeneous media as well as for mobility across
heterogeneous media (e.g., from one AR with WCDMA-based
Access Point/s to an AR with WLAN based Access Point/s).

Advantages of the structure and method according to the
15   invention over hierarchical-LMMs are the following:
-no need for configurations (in the current hierarchical-LMM
drafts, e.g. in MIPv6RR, each regional aware router in the
hierarchy needs to be configured with the addresses of the
direct descendants);
20   -no need for extensions to router advertisements which take
up radio resources;
-no need for additional binding updates (or extensions to
binding updates) over the air (additional to those required
by Mobile IPv6 and Fast Handovers);
25   -all the functionality needed to limit the propagation of BUs
to peer nodes can be provided in the access routers. The
mechanism is transparent to the rest of the internet, thus
all routers in the network can be standard IP routers;
-there is no single root node at the top of the hierarchy
30   which acts as the GMA/MAP. The tunnel endpoint in the flat-
LMM case is distributed across different ARs for different
MNs. This leads to better scalability;
-no need to set up a second care-of address (regional CoA,
Care of Address) (in HMIPv6 this is explicit - a MN has to
35   set up a unique regional CoA, with all the associated

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signaling. In MIPv6RR this is not such a problem since all
MNs under the same GMA use the same regional CoA);
-the flat-localized mobility management provided by the
invention requires only very minor changes to Mobile IPv6 and
5   Fast Handovers for Mobile IPv6 (no need for a completely new
protocol);
-the flat-localized mobility management provided by the
invention is not dependent on domains advertised through
extensions to Mobile IPv6 Router Advertisements, but on
10  timers which limit the frequency at which a MN is allowed to
send BUs to its HA and CNs. This feature can be used to
ensure that BUs are not received at the HA and CNs at a
frequency higher than a certain threshold. This benefit is
not possible with hierachical LMMs based on domain
15  advertisements;
-simplified security associations between network elements
and mobile node. The MN can either operate as in the base
Mobile IPv6, or it can send BUs to previous access routers,
with which it was already communicating before. Thus, there
20  is no need to introduce and rely on complex key districution
mechanisms;
-less states are required in the Local Mobility Agents since
states are only required for fast moving MNs. States for slow
moving MNs are mainained only at the HA and/or CNs.

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## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates a basic structure of a communication
30  system and outlines the basic operation of LMMs based on
hierarchy,

Fig. 2 shows an operation of a hypothetic network using
base Mobile IP and Fast Handovers (with no LMM),

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Fig. 3 shows the operational principle of of an
embodiment according to the invention of a method and system
incorporating the proposed flat-LMM mechanism (option 2),

5      Figs. 4 and 5 show signaling diagrams for flat-LMM
mechanism of embodiments for option 1 and option 2
respectively, according to the invention,

Fig. 6 is related to IP termination to the access router
10   (i.e. IP BTS), 2 level tracking in L2 and IP,

Fig. 7 illustrates a preferred embodiment of the
invention, and shows the overall principle of disassociation
of L2 from the L3,

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Fig. 8 illustrates the disassociation of layer L2 from
layer L3 in a more detailed view,

Fig. 9 shows the functioning of an embodiment and
20   illustrates the signaling for RRA updating in case the user
crosses the RRA boundary,.

Fig. 10 shows the functioning of an embodiment and
illustrates the signaling for subsequent RRA updating, and

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Figs. 11, 12 show the IP and L2 tracking in 2 levels
implemented in embodiments of the invention.

30          **DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE
INVENTION**

Generally, the invention regards a mechanism to overcome the
problems associated with Mobile IP under frequent change of
35   care-of address by the Mobile Node (MN). In the examples

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below Mobile IPv6 is used but it should be noted that the
invention may be implemented as well with other protocols
like Mobile IPv4. Aspects of the invention are shortly: while
the MN is changing cell it creates the new care-of address
5    (CoA) as in standard Mobile IPv6 but it does not send the
binding updates (BU) to Home Agent (HA) or to Correspondent
Node (CN). Instead it sends BU to the old Access Router (AR)
or it does not send a BU at all (additional to the fast-BU
between the new- and old- AR) in case of Fast Handovers
10   (Internet Draft). The invention introduces a mechanism based
on Access Router (AR) anchoring built on augmentations to the
Fast Handovers mechanism (Internet draft). Different
heuristics are presented on which the Anchor Access Router
(AAR) could be relocated. Two options are described which
15   could be used to avoid multiple levels of re-encapsulation
which could be caused by multiple forwarding.

This invention also introduces an associated mechanism to
support paging when a MN is in idle mode, thus limiting
20   unnecessary network overhead used for tracking idle MNs and
also increasing the lifetime of MN's battery. An "A" flag in
the Mobile IPv6 router advertisement could be added in the
currently unspecified bits to notify the mobile nodes that
this particular Access Router supports anchoring. Then MN may
25   decide to send the BUs to the Anchor AR while it changes the
access routers. The MN may decide to relocate its anchor
Access Router, based on layer 2 (L2) location areas (eg, URA
(registration area in the Universal Mobile Telecommunications
System (UMTS))), or based on the number of access router
30   hops, or depending on the interval since its last change of
care-of address for example.

The described embodiments of the invention are based on a
mechanism for creating forwarding paths between MN's care-of
35   addresses and thereby improving handoff smoothness in Mobile

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IPv6, and provide a solution to the problem of limiting the
BUs which need to propagate to the HA and CNs. Fast and
smooth handoff problems can be handled according to the
solution proposed in IETF, i.e. "Fast Handovers for Mobile
5    IPv6".

With the flat-LMM concept provided in the embodiments, there
is no node at the root of the hierarchy which acts as a
GMA/MAP. The operation of the Anchor Access Router (AAR) in
10   the flat-LMM is very simple and can thus be implemented in
all Access Routers. The operation of the AAR is simply the
same basic operation of a standard AR with an additional
embedded MIPv6 binding cache which enables the AAR to receive
BUs from the MN and forward packets to the MN even while the
15   MN is no longer within the subnet formed by that AR.

If the concept of using Regional Forwarding is implemented to
prevent multiple levels of re-encapsulation, then the ARs
also need to implement Regional Forwarding. It should be
20   noted that the Regional Forwarding mechanism is not required
if each Access Router decapsulates the tunneled packets
before re-encapsulating them.

Fig. 1 outlines the basic operation of LMMs based on
25   hierarchy. Notice that while the MN roams within the same
hierarchical domain (with the same LMGW as root) the MN only
sends regional binding updates. When the MN changes domain it
sends BUs to its HA and CNs. In the figure the Local Mobility
Gateway (LMGW) is a node which renders the frequent change of
30   care-of address of fast moving mobile nodes transparent to
nodes topologically farther from the mobile node (s.a. the
Home Agent). In order to minimize signaling latencies a LMGW
should be as topologically close to the mobile node as
possible. In the embodiments of the invention the LMGW
35   resides in the AAR and is dynamically assigned on a case-by-

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case basis (i.e. slow moving MNs do not use a LMGW). In
Hierarchical Mobile IPv6 the LMGW is equivalent to the MAP,
and in Mobile IPv6 Regional Registrations the LMGW is
equivalent to the GMA.

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In all drawings, the same MN is shown several times, each at
different subsequent time points t1 to t4, as also indicated
by an arrow "TIME" in Figs. 1 to 3. Figs. 4, 5 represent the
time axis from t=t0 to t=t4 in a downward direction.

10

Fig. 2 shows the operation of a hypothetic network using base
Mobile IP and Fast Handovers (with no LMM). Note that the MN
needs to trigger MIPv6 signaling with the HA and CN at each
change of AR.

15

Fig. 3 shows the operational principle of preferred
embodiments of the invention which include the proposed flat-
LMM mechanism (option 2, i.e. BUs but no Regional
Forwarding). A detailed description of the mechanism is given

20   below. Note that the MN is required to trigger Mobile IPv6
signaling only when the Anchor Access Router is relocated.

Figures 4 and 5 show the signaling diagram for the flat-LMM
mechanism, described below, for option 1 and option 2

25   respectively.

As discussed above, Fast Handovers for Mobile IPv6 alleviates
delay and packet loss problems presented above but currently
does not tackle the signaling overhead problem. This can be

30   seen in Fig. 2. End-to-end Mobile IPv6 signaling has to take
place at each change of Access Router. Although in most cases
the overhead associated with this signaling can be reduced by
synchronizing the binding messages to higher layer payloads,
this is in some cases not feasible. Even if all binding

35   messages can be synchronized to higher layer payload, some

mechanism would still be needed to limit the processing
overhead at correspondent nodes. Thus, it is still desirable
to limit this end-to-end signaling, particularly when the MN
changes Access Routers very frequently.

5

The invention thus proposes, according to one aspect, a
mechanism for limiting the end-to-end signaling based on
anchoring of Access Routers (see Fig. 3). A MN is initially
attached to AR1 (time = t0). Subsequently (time = t1) it
10    hands-over to a new cell which is controlled by a new Access
Router (AR2). The MN proceeds by forming its new care-of
address as in standard Mobile IPv6. The MN however makes a
decision that instead of sending BUs to its peer nodes (HA,
CNs) it will send a BU to its previous Access Router, or no
15    BU at all (additional to the fast-BU) in the case of Fast
Handovers. In the latter case, the old Access Router will
learn the new MN's care-of address through Fast-BU specified
in IETF proposal. The only difference proposed by the
invention is that the MN will not subsequently send a BU to
20    its peer-nodes (HA, CNs). An "A" flag in the Mobile IPv6
router advertisement could be added in the currently
unspecified bits to notify the mobile nodes that this
particular Access Router supports anchoring.

25    The MN may decide to relocate its anchor Access Router, based
on L2 location areas (eg, URA), or based on the number of
access router hops, or depending on the interval since its
last change of care-of address for example. This is discussed
in more detail below.

30

One of the aims of the flat-LMM concept is to minimize the
propagation of BUs to HA and CNs. The basic algorithms
outlined below are enough to serve the purpose. The problem
of minimizing latency and packet loss may be handled by the
35    Fast Handovers mechanism.

19

In the following, details for limiting the frequency of BUs
sent to HA and CNs will be discussed. The following basic
algorithms can be used as a basis for the decision of when to
5    use Acess Router Anchoring and when to revert back to normal
Fast Handovers + Mobile IPv6 operation (i.e. sending BUs to
HA and CNs):

- maintaining a timer (t) to measure the interval since the
    last delivery of a BU to HA/CN
10       if t > threshold
        normal Fast Handover + MIPv6 operation
    else
        normal Fast Handover + MIPv6 operation but without
        sending BU (or send BU to AAR, depending on which option
15      (see below) is selected
    end


AND/OR


20   - maintaining a counter (c) in the MN to keep track of the
    number of L3 handovers for which the same AAR was kept. If
    the AAR is too far away (in terms of number of L3
    handovers) then relocate the AAR.


25   AND/OR


    - the MN may also take into consideration the number of CNs
    with which it has ongoing sessisions when making the decision
    about whether or not to use the AAR. If the number of CNs is
30   above a certain threshold (n), then in order to save air
    interface resources (mainly), the MN will decide to use the
    AAR, in which case only one BU will be sent.


    In practice, a combination of the above methods/algorithms
35   will give even better results. Selection of the threshold

20

values and their corresponding weightings, leading to the
most optimal results can be found empirically through
implementations and/or simulations.

5   At some stage, e.g. when reaching a threshold set for the
selected or more of the above mentioned algorithm(s), the MN
may decide that it is time to relocate its Access Router. In
this case it will follow standard Mobile IPv6 Fast Handover
Procedure, and will send a Binding Update to its peer nodes
10  (HA and CNs).

In the following, options for limiting multiple levels of re-
encapsulation are discussed which represent optional features
of the invention (this problem could also be solved if the
15  Access Routers decapsulate the tunneled packets before re-
encapsulating them).

Two alternative mechanisms are proposed to avoid this
problem, i.e. to limit multiple levels of re-encapsulation.
20
The first option is to apply address swapping as used e.g. in
Mobile IP Regional Forwarding (J.T. Malinen, C.E. Perkins,
"Mobile IP Regional Forwarding", Internet Draft).

25  The second alternative consists in that the MN keeps record
of the address of the anchor Access Router, and uses this
address as a primary Anchor Access Router (i.e. the MN always
signals its movement to this Access Router). At time = t2,
the MN hands-over to a cell controlled by AR3. The MN still
30  chooses to use AR1 as its anchor point. Thus, during the Fast
Handoff mechanism it sends its Fast-BU to AR1 instead of AR2.
This way, only one extra tunneling header will be required
(similar to HMIPv6). If an address swapping mechanism such as
that proposed in J.T. Malinen, C.E. Perkins, "Mobile IP
35  Regional Forwarding", Internet Draft, is used, then no

additional tunneling overhead will occur.

Fig. 4 illustrates the functioning of an embodiment
incorporating a function according to option 1. The signaling
5    and message flow (data flow) as well as the meaning of the
actions shown in Fig. 4 is self-explanatory from the arrows
and inscriptions used in Fig. 4. Fig. 4 thus represents full
disclosure of the details of this embodiment of the
invention.

10

The functioning of Fig. 5 embodiment corresponds to the basic
The functioning corresponds to the basic Fast Handover +
MIPv6 operation, with the following modifications:
-    ARs advertise the support of flat-LMM with an "A" flag
15       which replaces one of the currently unused bits in the
MIPv6 router advertisements;
-    ARs implement Regional Forwarding to avoid multiple levels
of re-encapsulation;
-    MN implements a heuristic algorithm (eg. as given above)
20       to determine when to send BUs to HA and CNs (in the
example embodiment of Fig. 4 this happens when MN moves to
AR5).

Fig. 5 illustrates the functioning of an embodiment
25   incorporating a function according to option 2. The signaling
and message flow (data flow) as well as the meaning of the
actions shown in Fig. 5 is self-explanatory from the arrows
and inscriptions used in Fig. 5. Fig. 5 thus represents full
disclosure of the details of this embodiment of the
30   invention.

The functioning of Fig. 5 embodiment corresponds to the basic
Fast Handover + MIPv6 operation, with the following
modifications:
35   -    ARs advertise the support of flat-LMM with an "A" flag

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which replaces one of the currently unused bits in the
MIPv6 router advertisements;

- MN records the address of the AAR and sends its BUs to
  that address as opposed to the HA/CNs;

5 - In this case only 1 extra encapsulation occurs (at the
  AAR). If this is an issue then the ARs can implement the
  address swapping mechanism used in Regional Forwarding
  (without need for a full Regional Forwarding
  implementation, since there is no need for the mechanism
10  that sets up (or updates) the binding cache (hop-by-hop)
  in RegFwd);

- In this case the AAR can refuse to act as an anchor AR by
  sending a Negative BAck, with a new error message (eg "AR
  not willing to server as Anchor"). In that case the MN
15  will revert back to standard Fast Handover + MIPv6
  operation, i.e. sending a BU to the HA/CNs.

In the embodiment of Fig. 5 implementing "Option 2" no
multiple levels of address swapping is needed. In MIPv6RR
20 multiple levels of address swapping is the only option.

The operation in Idle mode will be described next. The
signaling overhead in support of the Mobile IPv6 mobility
management will grow linearly with the number of MNs in the
25 network. The vast majority of wireless IP subscribers will
not be actively communicating most of the time. Rather, MNs
will be in an idle state (power saving), i.e. passively
connected to the network. As a result, it will be sufficient
for the network to know the approximate location of idle MNs.
30 The exact location of the MNs only becomes important when
data needs to be forwarded to them, in which case the network
protocols need to be able to efficiently search and find
these users in a scalable and timely manner. This process is
not new in cellular networks and is referred to as paging.

35

23

The invention proposes to extend the above presented basic
structure in order to incorporate paging mechanism which
ensures to achieve the above mentioned advantages. L2 Access
Points attached to Access Routers are organized in

5    Registration Areas (RAs) which are similar to UTRAN
Registration areas (URA) in UTRAN and GERAN Registration
Areas (GRA) in GERAN. The identity of the RRA is advertised
over broadcast channel by each Access Point. In order to
integrate radio technologies which do not make use of such L2

10   areas (eg WLAN) in this mechanism, these registration areas
can be IP based (but still sent over broadcast channels s.t.
the MN can listen to them when idle). If the MN is in idle
state, it is not required to send any binding updates (either
to the peer nodes or to the AAR) as long as it stays within

15   the same RA as its AAR. If the MN was not using an AAR before
going idle, then the last AR where the MN was last seen
active takes its role. When an idle MN changes RAs it sends
BUs as in standard MIPv6, i.e. to its HA. The HA thus always
knows the location of the MN to the acuracy of the RA.

20

If a new CN initiates a new session towards the MN the
traffic will first reach the HA, where it will be diverted
towards the last registered care-of address which should
point to an Access Router in the MNs current RA. When the AR

25   receives such packet/s, after determining that the MN does
not have a radio bearer at any of the Access Points attached
to it, the AR will initiate paging across the whole RA. In
cellular systems that already support paging (WCDMA, EDGE,
etc...) this could be a L2 paging message. In other

30   technologies which do not currently support paging at L2,
some IP paging message can be defined. On reception of such a
paging message the MN initiates a radio bearer establishment
and sends a BU to the AAR so that packets can be forwarded to
the MN's current AR. Subsequent to this, the MN preferably

35   sends BUs to the HA and CNs in order to establish optimal

routing paths.

The invention has impacts on the architectures selected for
full-IP architectures based on Mobile IP (IPv4 or IPv6). In

5    the described embodiments all the required functionality
resides in the Access Routers. There is no need for any
specialized nodes (GMA/MAP etc…) in the architecture.

Since the mechanism presented in this embodiments functions

10   at the IP layer, it is just as suitable for localized
mobility management across homogeneous media as it is for
mobility across heterogeneous media (eg, from one AR with
WCDMA-based Acess Point/s to an AR with WLAN based Access
Point/s).

15

The intelligence needed in the MN is not much more
complicated than a simple operation for implementing the
above timer or counter function.

20   The flat-LMM mechanism is not based on host routes. It is
instead based on binding caches. The difference from the
above is that binding cache entries are not propagated by
routing protocols. Thus there are no instability problems.
Regarding the number of entries in each binding cache, in the

25   flat-LMM case there are less entries/cache as compared to
hierarchical-LMMs since there is no root node at the top of
the hierarchy which maintains all the address mappings for
the MNs in that domain. The binding caches are distributed
across the ARs and thus more scalable.

30

The embodiments of the invention shown in the drawings and
described above as well as in the following, relate to area
where the mobile network design is based on the IP mobility
mechanisms, e.g. Mobile IPv6. The main access technologies

35   (Layer 2 protocols) which are considered in the following

25

text are GSM and WCDMA.

The user IP is terminated to the access router (the text uses
term IP BTS which is a combination of the AR and BTS
5      functionality) (contrary to the current GPRS where the user
IP is terminated to the GGSN) in the network side. This means
that IP packets to the user are always routed to the access
router. In some case there exists already L2 resources (i.e.
radio resources for radio bearers) for sending the data over
10     the air. Typical example of this is an active data
transmission.

Note that the access router and base station (BTS) may be in
different network entities.
15
However, in some cases there may not be L2 resources
available and also it may be that the terminal location is
only known in some L2 location management function. L2
location management may be based on updating the location
20     information to the network where the reported area is RRA
(RAN Registration Area, which is like UTRAN Registration Area
in WCDMA. Therefore the IP BTS must page the user before in
order to locate the user after which the IP BTS may allocate
resources for the user in order the data can be sent to the
25     user over the air.

Fig. 6 is related to IP terminated to the access router (i.e.
IP BTS), 2 level tracking in L2 and IP, and shows a case
where the user starts to receive IP packets from the network.
30     The state information (e.g. Packet Data Convergence Protocol
(PDCP), Radio Link Control / Media Access Control (RLC/MAC),
security and location) of the user (MN) is maintained in the
IP BTS 1 while the user is under IP BTS 2. In this example
also the Radio Resource Control (RRC) is maintained in IP BTS
35     1. The question mark in the figure 6 shows that in this

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example the IP BTS 1 does not know the physical location (L1 information) of the MN. The user needs to be paged from the RRA and when the MN of the user responds to the paging the handover needs to be executed to the IP BTS 2.

5

When the terminal enters new RRA area it updates its location to the network (RRA Updating), i.e. the location database "Location db" in the IP BTS 1. The IP BTS may contain the location information of the certain area, i.e. certain RRAs.

10      The user may enter regions for which the location information is stored in another database in another IP BTS than the one where the location information of the user was stored before the user entered the new region.

15      In this case, the (L2) information regarding the user is moved to the new IP BTS as shown in Fig. 7. In the IP level the change of the IP BTS typically means the change of the CoA of the user. Therefore, the user needs in addition to the RRA update send the BUs to all CNs.

20

As the sending BUs to CNs increases the signaling load over the air it is in some cases useful to allow a disassociation of L2 from L3. This means that the L2 context of the user is moved to the new IP BTS while on the L3 level the user is

25      still in the old IP BTS. In order to route the IP packets correctly to the user, the old IP BTS updates the new forwarding IP address where to forward the IP packets coming to the CoA in the old IP BTS ("L3 Forwarding" of Fig. 7).

30      Fig. 7 illustrates the disassociation of the L2 from L3, and shows the overall principle what is meant by the disassociation of L2 from the L3. This embodiment of Fig. 7 is a preferred embodiment of the invention.

35      The vertical line of Fig. 7 symbolizes the border between

27

RRA1 and RRA2.

Fig. 8 illustrates the disassociation of layer L2 from layer
L3 in a more detailed view. In this case the user MN is
5    attached to IP BTS3 and receives IP packets via IP BTS 1 and
IP BTS 2. The Binding cache of BTS 1 includes the information
"Next hop=IP BTS 2".

Fig. 9 shows the signaling for RRA updating in case the user
10   crosses the RRA boundary. The user updates its new RRA
location to the network containing the Radio Network
Temporary Identity (RNTI, this is L2 identity used for the
user) and old RRA location (message "1. RRA Update [RNTI, old
RRA]" sent from User to IP BTS new/AR new). The new IP BTS
15   allocates an IP address where it is ready to receive
forwarded IP packets tunneled from the old IP BTS. The new IP
BTS IP sends message "2. RRA Update [RNTI, forwarding IP
Address]" to BTS old/AR old. Note that the IP address can be
allocated later from the new IP BTS/AR new by making an
20   additional roundtrip between the old and new IP BTS/AR.

The old IP BTS makes binding from the CoA to the new
forwarding address (3. Establish binding info CoA ->
forwarding IP]". When the old IP BTS receives packets sent to
25   the user to the CoA it tunnels the packets to the new
forwarding IP address.

When the old IP BTS receives the RRA Update it sends the L2
information, e.g. radio bearer (RLC/MAC), terminal
30   capability, security parameters and header compression info,
to the new IP BTS ("4. RRA Update Ack [L2 info]").

It is a possibility that there is no L3 information forwarded
to the new IP BTS at this point. It is also possible to
35   forward some L3 level information e.g. QoS information

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(Differentiated Services Code Point, DSCP) and security
information.

5    The new IP BTS acknowledges the RRA updating to the user ("5.
     RRA Update Ack [new RRA]").

     From the L2 point of view the user is now in the new RRA
     while in the L3 the user still has the old CoA in the old IP
     BTS.
10
     Fig. 10 shows the subsequent RRA updating case which occurs
     when the user changes RRA while L3 and L2 are already
     separated in the previous RRA updating (see Fig. 9).

15   The user updates its new RRA location to the network by
     sending RRA Update message 1 containing the Radio Network
     Temporary Identity (RNTI) and old RRA location. The new IP
     BTS allocates an IP address where it is ready to receive
     forwarded IP packets tunneled from the old IP BTS, and sends
20   RRA Update message 2 to the old IP BTS indicating RNTI and
     Forwarding IP address. Note that the IP address can be
     allocated later from the new IP BTS/AR new by making an
     additional roundtrip between the old and new IP BTS/AR.

25   The old IP BTS updates the old forwarding IP address to the
     new forwarding IP address, and sends RRA Update message 3 to
     the other old IP BTS which forwards the IP packets for the
     user. The latter IP BTS makes binding from the CoA to the new
     forwarding address (event 4). When the forwarding IP BTS
30   receives packets sent to the user to the CoA it tunnels the
     packets to the new forwarding IP address.

     When the old IP BTS receives the RRA Update Ack (message 5)
     it sends the L2 information, i.e. radio bearer (RLC/MAC),
35   terminal capability, security parameters and header

                                29

compression info, to the new IP BTS (message 6). It is
possible that there is any L3 information forwarded to the
new IP BTS at this point. It is further possible and
beneficial to forward e.g. QoS information (DSCPs) and
5   security information.

The new IP BTS acknowledges the RRA updating to the user
(message 7).

10  From the L2 point of view the user is now in the new RRA
while in the L3 the user still has the old CoA in the
forwarding IP BTS.

Alternative to the mechanism presented in the Figure 10 is
15  that when the new IP BTS allocates an IP address where it is
ready to receive forwarded IP packets tunneled from the old
IP BTS, it sends RRA Update message 2 to the old IP BTS
indicating RNTI and Forwarding IP address. The old IP BTS
stores the new forwarding IP address, and sends RRA Update
20  Ack message back to the new IP BTS. In this way the IP packet
is routed via two old IP BTS/AR to the new IP BTS/AR.

The invention provides a new network architecture design.

25  The proposed solution combines current GSM and WCDMA radio
concept with the MIPv6 concept.

Fig. 11 shows a table which combines the IP and L2 levels (IP
and L2 location tracking in 2 levels) and describes each of
30  the possible combination state. The columns of Fig. 11
represent L2/IP; L2 released; Cell; and RRA. The indications
in the table are self-explanating and thus do not need to be
repeated here; the disclosure contents of this table as well
as of any other of the attached Figs. being fully
35  incorporated into the disclosure of the present invention.

Fig. 12 shows the contents of the table of Fig. 11, i.e. IP
and L2 tracking in 2 levels, in a state diagram format.

Note, that in Fig. 12, the term handover is used for a case
5    where the cell and/or access router (i.e. IP BTS) is changed
while there is an active data transmission. Also in the case
when there is no data transmission (i.e. L2 RRA state) the
handover term is used but it differs from the original idea
of the handover and may also be termed e.g. "a change of the
10   cell and/or access router" or "camping to a new cell/access
router".

One skilled in the art knows that the invention can be used
in other mobile networks also (including WLAN, IP RAN, UTRAN,
15   GERAN, EDGE etc. based networks).

Although the invention has been described above with
reference to specific embodiments, the scope of the invention
also covers any alterations, additions, modifications, and
20   omissions of the disclosed features.

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## CLAIMS

5

1. Method for managing data flow between Mobile Nodes
(MNs), Access Routers (AR) and peer nodes (HA, CNs), the
method comprising the step of:

when a Mobile Node makes handover from one Access Router
10   (AR) to new Access Router (AR2, AR3, … ARn) a decision is
made whether the first Access Router (AR1) should act as an
Anchor Access Router and forward data from the peer nodes
(HA, CNs) to the Mobile Node via the new Access Router (AR2,
AR3, …ARn), or to send an update of the new position of the
15   mobile node to a peer node (HA, CN), wherein the decision is
made based on at least one of the following criterias:

-the number of peer nodes (HA, CN1, CN2, ... CNn) to
which it has ongoing sessions,

-the time elapsed from a previous update sent to the
20   peer nodes (HA, CNs),

-the traffic activity between the peer node(s) (HA,
CN1, CN2, …CNn) and the Mobile Node (MN),

-traffic load, or signaling load between mobile node
and Access Router and/or peer nodes,

25   -the state of underlying layers, e.g.protocol layers
1 and/or 2,

-the state of the mobile node,

-the frequency of handovers.


30   2. A method according to claim 1, wherein the decision
is made by the Mobile Node.


3. A method according to claim 1, wherein the decision
is made by the Network.

35

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4. A method according to claim 1, wherein the decision
is made by an entity in access network.

5

5. A method according to any of the claims 1 to 4,
wherein the maximum number of handovers for which the same
Anchor Access Router is kept is restricted to a pre-defined
upper limit.

10

6. Method according to any one of the preceding claims,
wherein the communication between the Mobile Node(s), the
Access Routers (AR) and the peer nodes (HA, CNs) is effected
based on Mobile IP.

15

7. Method according to any one of the preceding claims,
wherein, when the Mobile Node has moved and selected a new
Access Router as Anchor Access Router, a Binding Update
message is always sent to the previous Access Router, the
20  decision on whether to send Binding Update messages being
always based on the criteria mentioned in claim 1, and/or on
the number of times a Care-of Address (CoA) has changed
without notifying a peer node.

25  8. Method according to any one of the preceding claims,
wherein, when the Mobile Node has moved and selected a new
Access Router as Anchor Access Router, a Binding Update
message is always sent to the Anchor Access Router, the
decision on whether to send Binding Update messages being
30  always based on the criteria mentioned in claim 1, and/or on
the number of times a Care-of Address (CoA) has changed
without notifying a peer node.

9. Method according to any one of the preceding claims,
35  wherein the handover of the Mobile Node from the first to the

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second Access Router is performed as defined in the Mobile IP
or Fast Handovers for Mobile IPv6.

10. Method according to any one of the preceeding
5    claims, wherein the peer nodes include a Home Agent (HA)
and/or a Correspondent Node (CN).

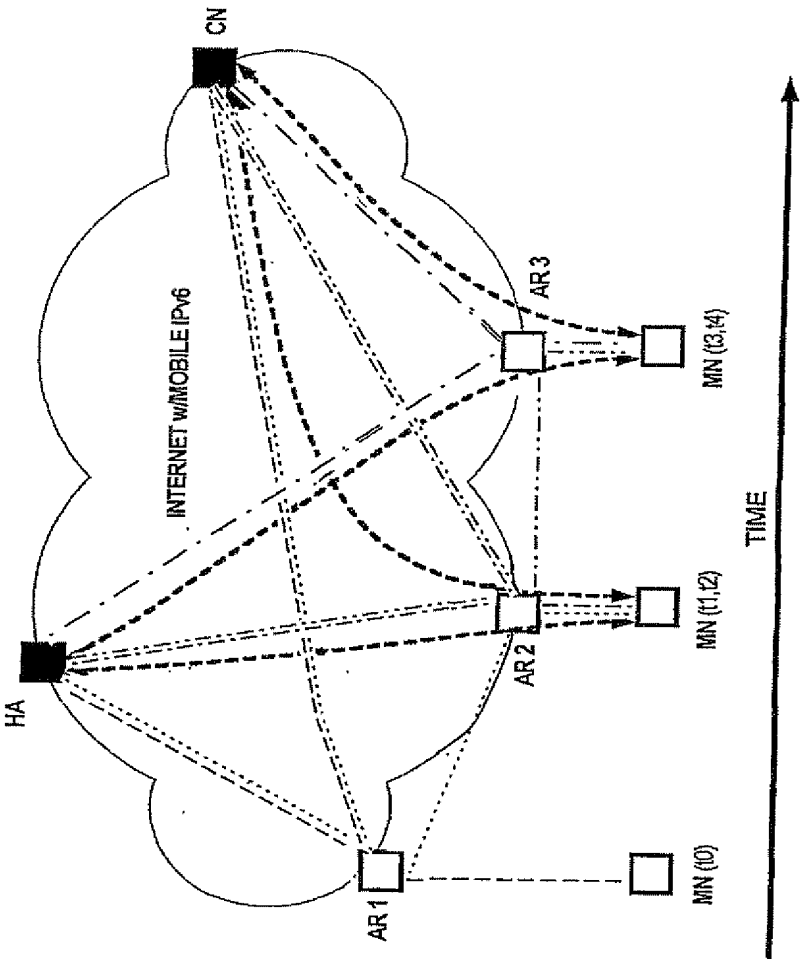11. System for managing data flow between Mobile Nodes
(MNs), Access Routers (AR) and peer nodes (HA, CNs),
10   comprising deciding means for deciding,
    when a Mobile Node makes handover from one Access Router
(AR1) to new Access Router (AR2, AR3, … ARn), whether the
first Access Router (AR1) acts as an Anchor Access Router and
forward data from the peer nodes (HA, CNs) to the Mobile Node
15   via the new Access Router (AR2, AR3, …ARn), or to send an
update of the new position of the mobile node to a peer node
(HA, CN),
wherein the decision is made based on at least one of the
following criterias:
20           –the number of peer nodes (HA, CN1, CN2, ... CNn) to
which it has ongoing sessions,
             –the time elapsed from a previous update sent to
the peer nodes (HA, CNs),
             –the traffic activity between the peer node(s) (HA,
25   CN1, CN2, …CNn) and the Mobile Node (MN),
             – traffic load or signaling load, between mobile
node and Access Router and/or peer nodes,
             –the state of the underlying layers,
             –the state of the mobile node,
30           –the frequency of handovers.

12. A system according to claim 11, wherein the deciding
means is provided in the Mobile Node (MN).

35   13. A system according to claim 11, wherein the deciding

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means is included in the Network.

14. A system according to claim 11, wherein the deciding means is included in an entity in access network.

5

15. A system according to any of the claims 11 to 14, wherein the maximum number of handovers for which the same Anchor Access Router is kept is restricted to a pre-defined upper limit.

10

16. A system according to any of the claims 11 to 15, wherein the Access router (AR) is a base station.

17. System according to any one of the preceding system
15  claims, wherein the system is adapted to perform a handover of the Mobile Node from one Access Router to another Access Router as defined in the Mobile IP or Fast Handovers for Mobile IPv6.

20  18. System according to any one of the preceding system claims, wherein the peer nodes include a Home Agent (HA) and/or a Correspondent Node (CN).
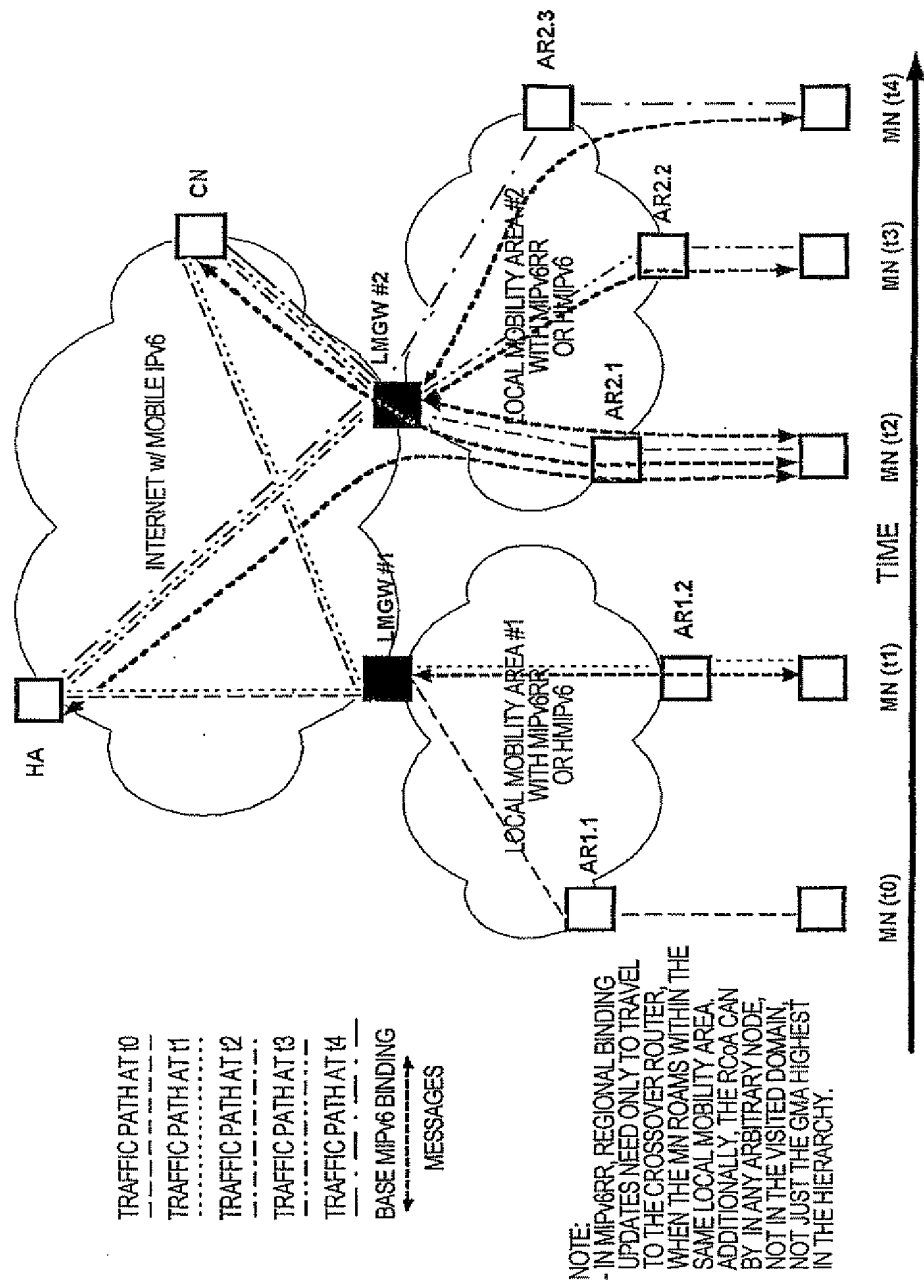
FIG. 1

PRINCIPLE OF LMMs BASED ON HIERARCHY

## FIG. 2

BASE MOBILE IPv6 WITH FAST HANDOVERS



INTERNET w/MOBILE IPv6

HA

CN

AR 1

AR 2

AR 3

MN (t0)

MN (t1,t2)

MN (t3,t4)

TIME

TRAFFIC PATH AT t0

TRAFFIC PATH AT t1

TRAFFIC PATH AT t2

TRAFFIC PATH AT t3

TRAFFIC PATH AT t4

BASE MIPv6 BINDING

MESSAGES

NOTE:
- FAST HANDOFF SIGNALLING
  NOT SHOWN IN THIS DIAGRAM.
  THIS WOULD REQUIRE AN ADDITIONAL
  3 MESSAGES TO BE SENT OVER
  THE AIR (F-BU, F-BACK AND F-NA)

# FIG. 3

"FLAT" LOCALIZED MOBILITY WITH FAST HANDOVERS



TRAFFIC PATH AT t0

TRAFFIC PATH AT t1

TRAFFIC PATH AT t2

TRAFFIC PATH AT t3

TRAFFIC PATH AT t4

BASE MIPv6 BINDING

MESSAGES
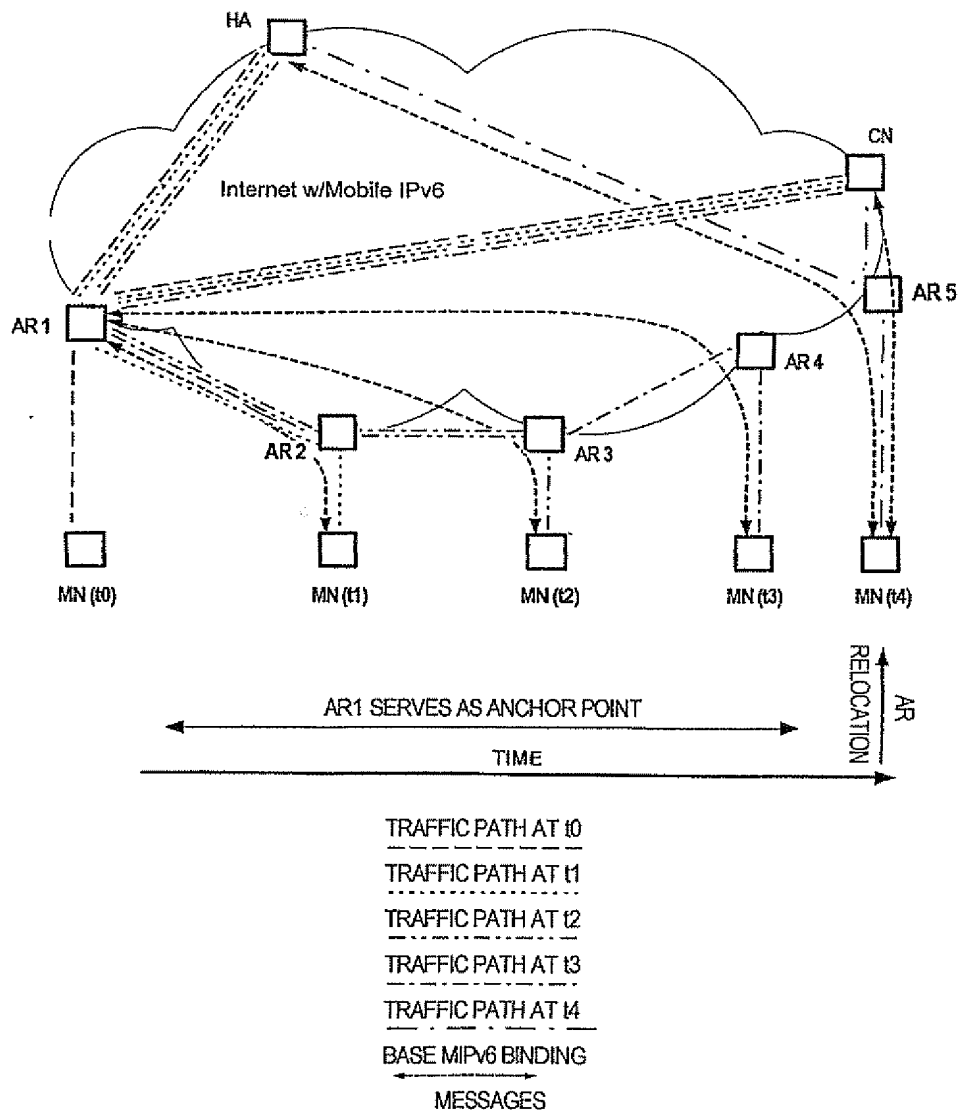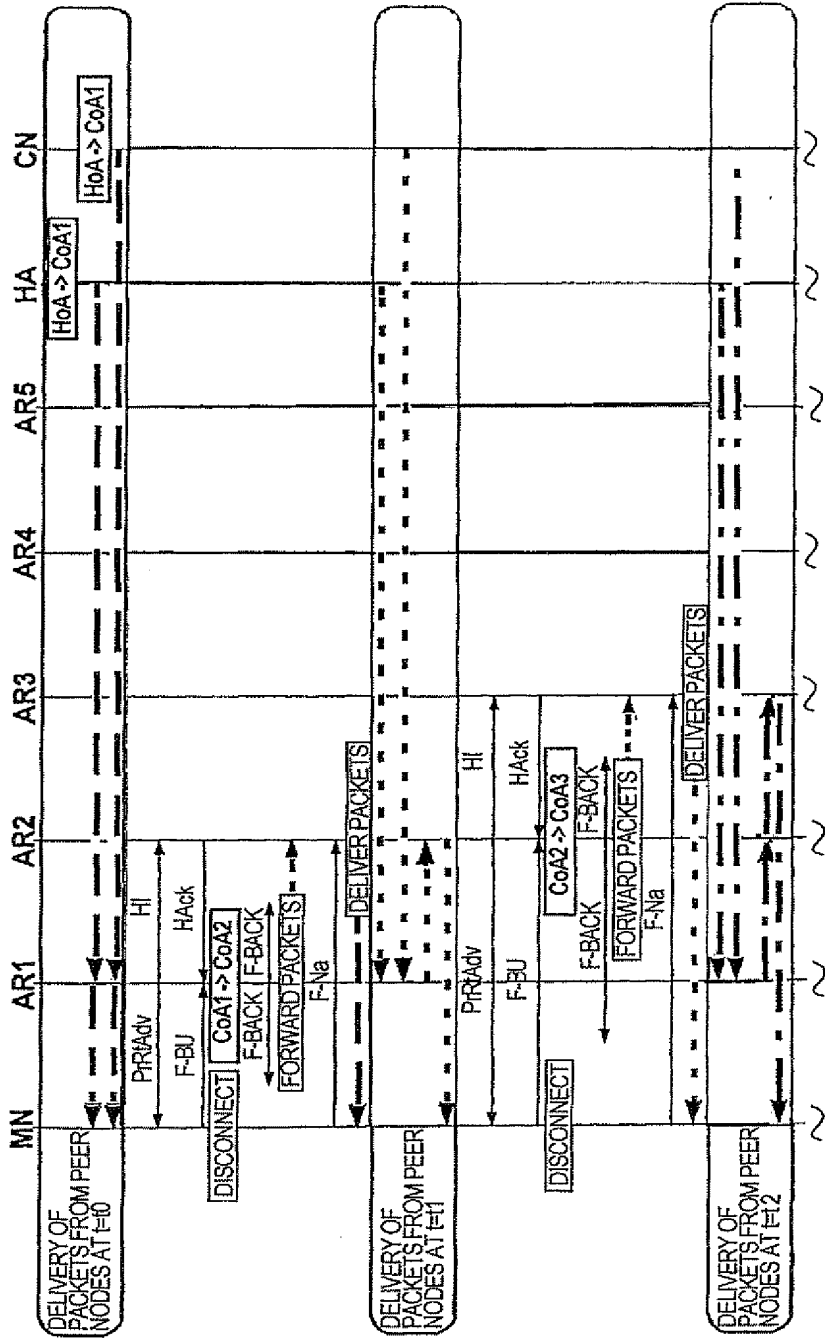
FIG. 4 A

OPTION 1 (NO BUs + REGIONAL FORWARDING)

FIG. 4

| FIG. 4A |
|---------|
| FIG. 4A |
| FIG. 4B |
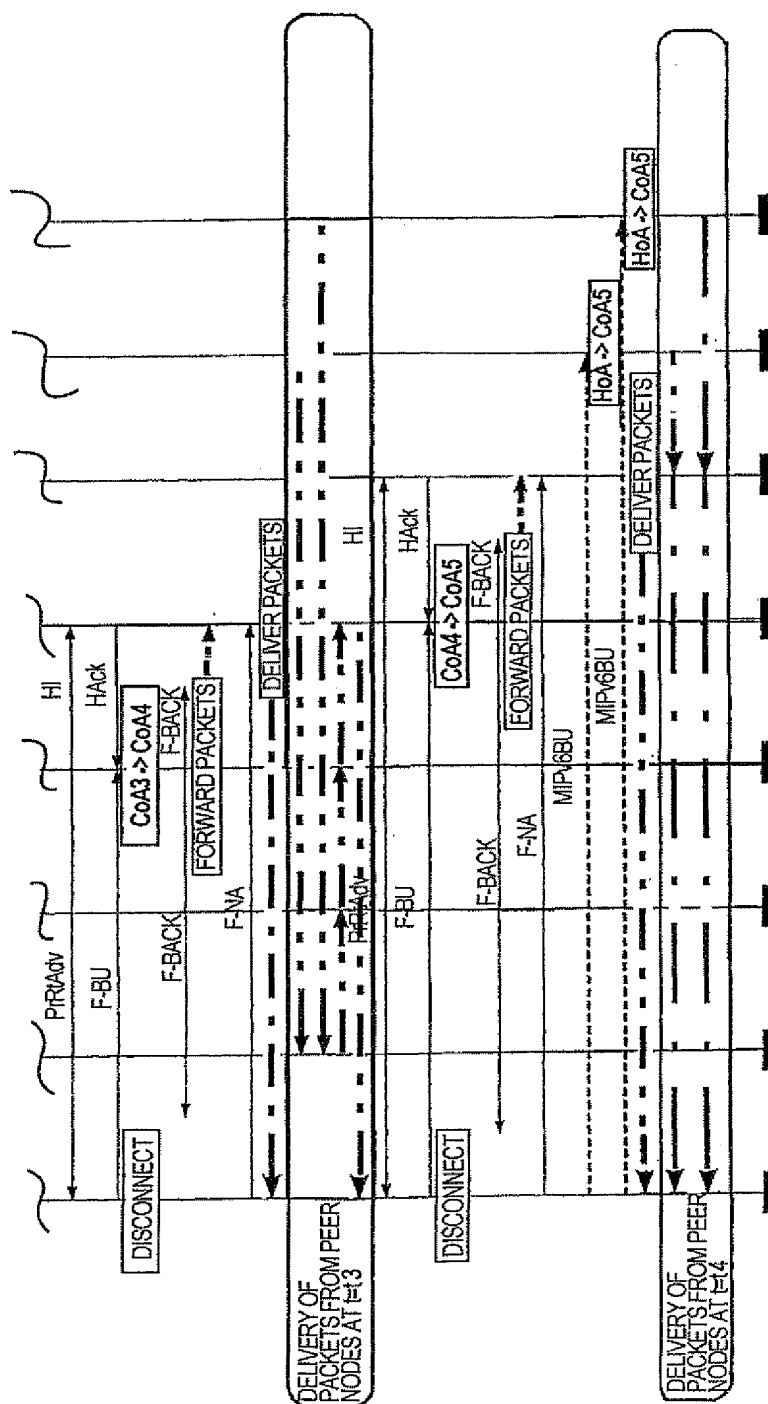
FIG. 4 B
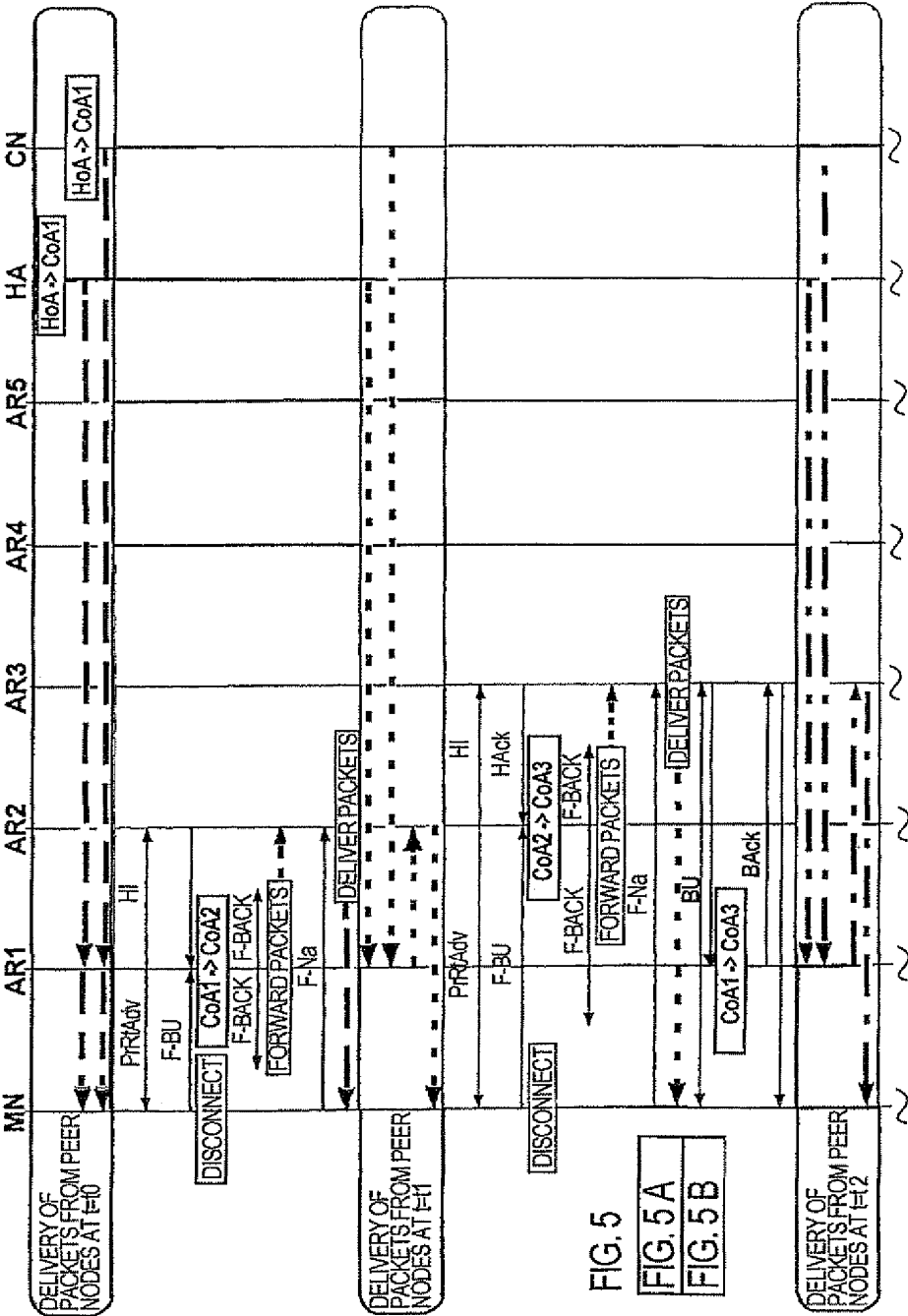
FIG. 5A

OPTION 2 (BUs +NO REGIONAL FORWARDING)

FIG. 5

| FIG. 5 A |
| FIG. 5 B |
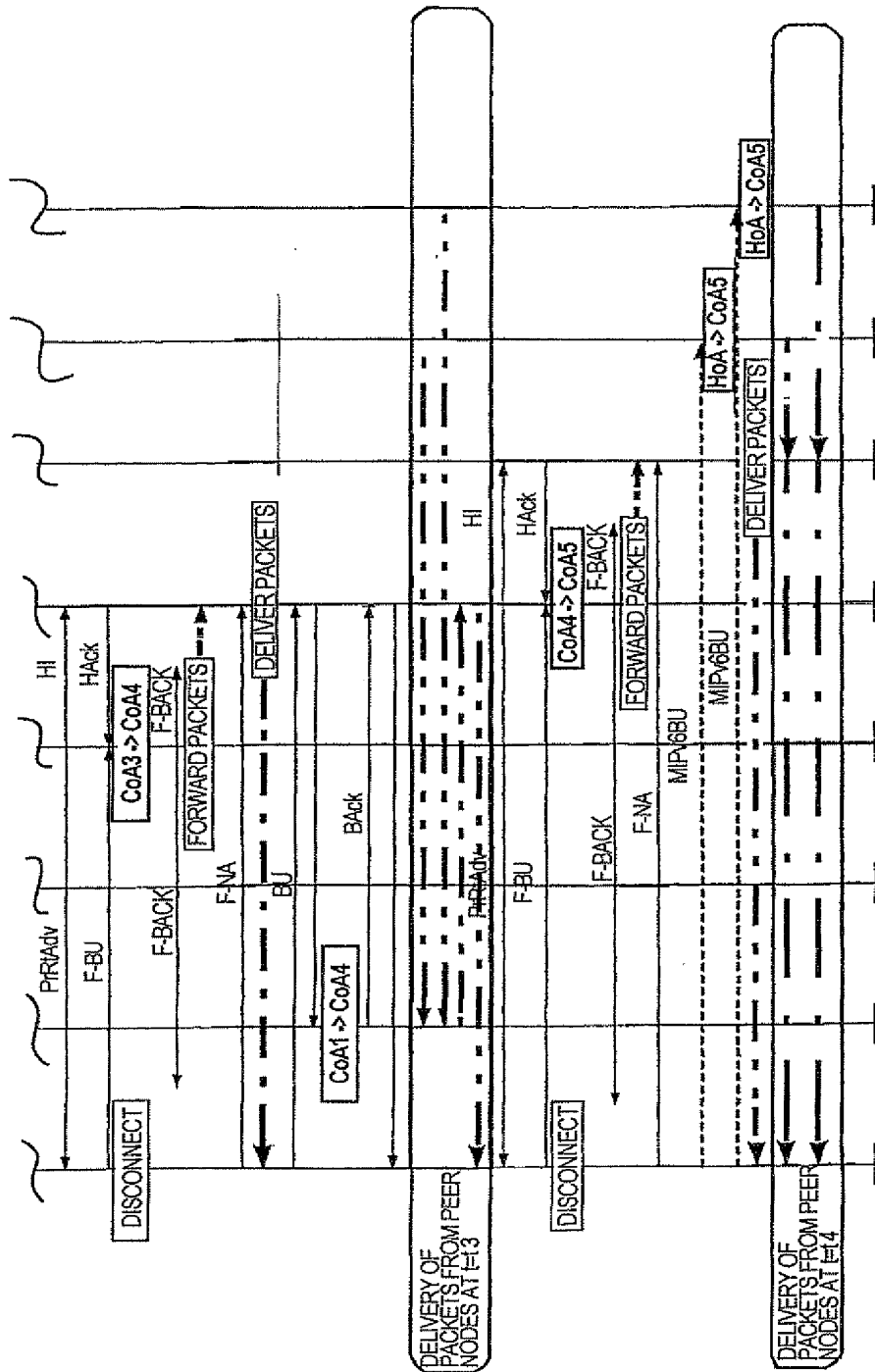
FIG. 5 B
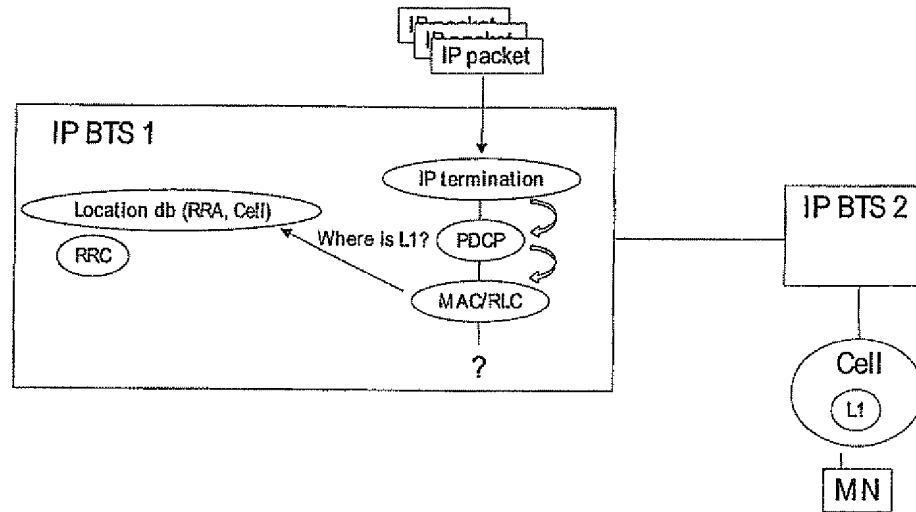
# Fig. 6

# IP terminated to the access router (i.e. IP BTS), 2 level tracking in L2 and IP
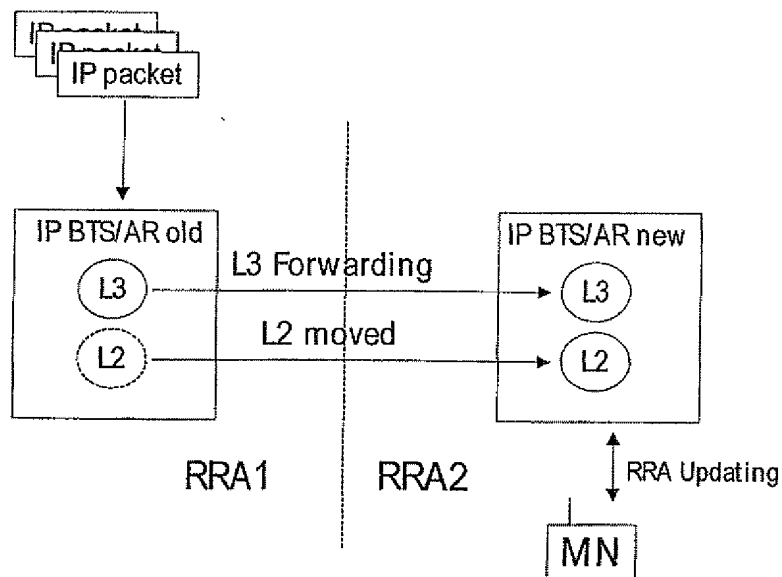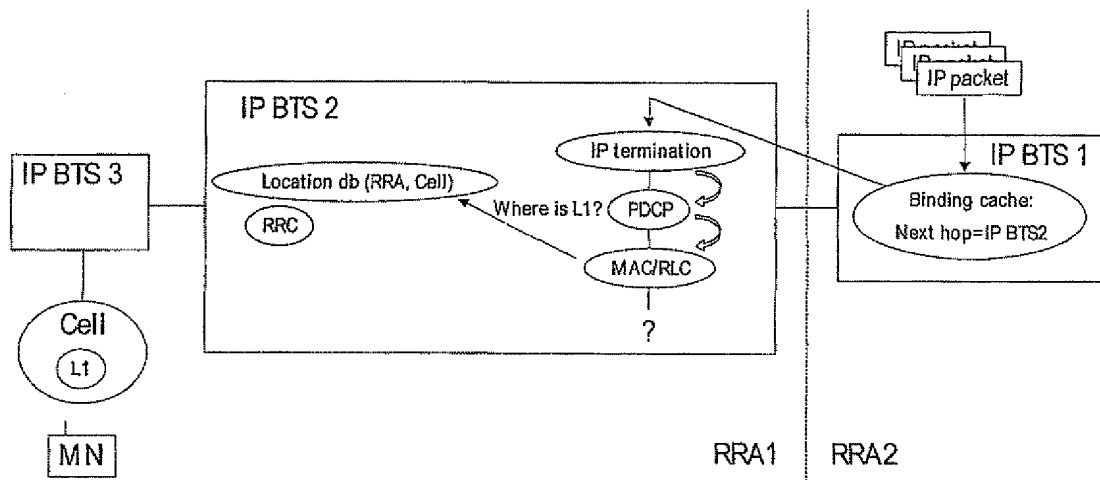


# Fig. 7

# Disassociation of L2 from L3

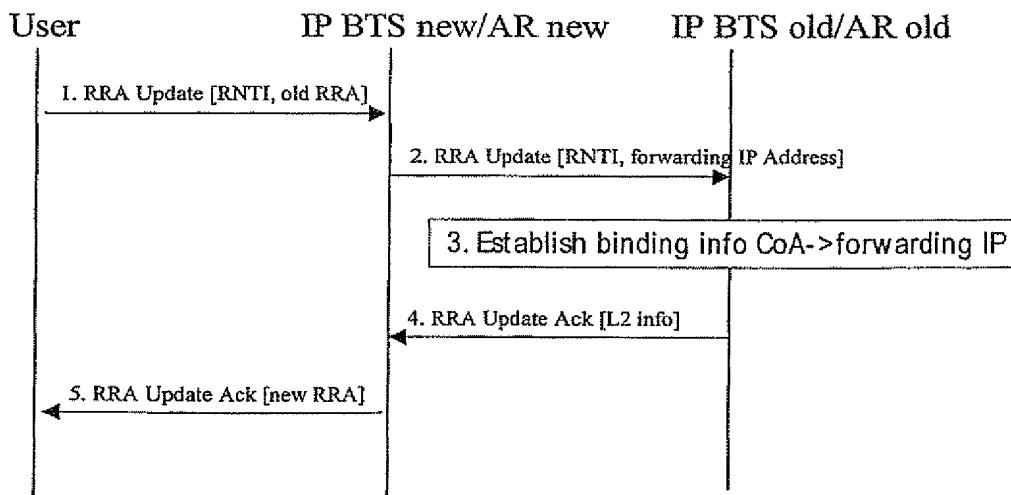## Fig. 8

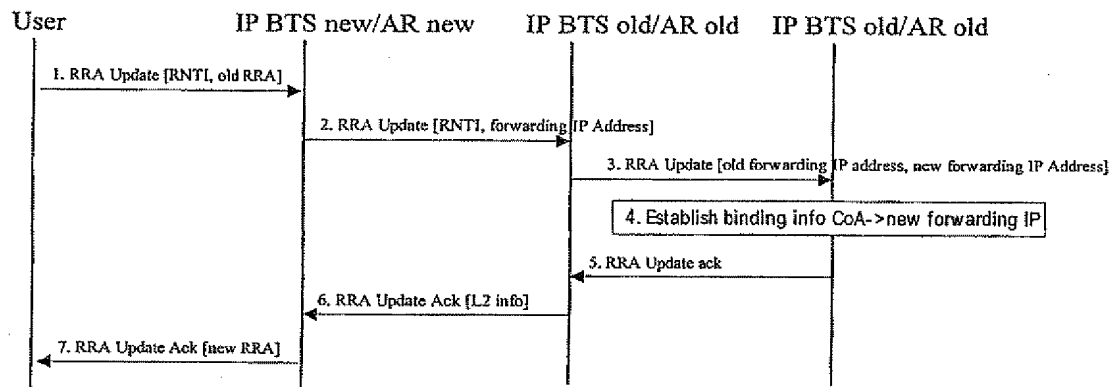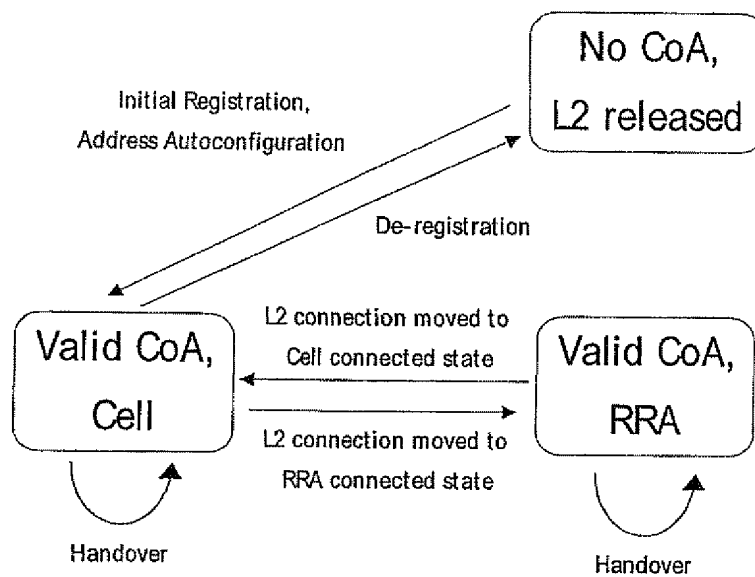## Disassociation of L2 from L3, more detailed view



## Fig. 9

## RRA Updating

# Fig. 10

# Subsequent RRA updating

| L2/IP | L2 released | Cell | RRA |
|---|---|---|---|
| No CoA | Terminal powered off | Terminal is performing address autoconfiguration. This may not need L2 if some L2 broadcast mechanisms are used. | Not possible (it's assumed that there is no reason to maintain L2 connection if the terminal does not have a valid CoA) |
| CoA | Not possible | Terminal is in a process of performing the registration when the access to the network is authorized. | Not possible (it's assumed that there is no reason to maintain L2 connection if the terminal does not have a valid CoA) |
| Valid CoA | Not possible | Terminal has performed a successful registration (BU to home network) and the location of the terminal is known in the cell level.<br><br>Information regarding the terminals connections are maintained in the network, i.e. IP BTS. The information contains L2 bearer information (e.g. PDCP and MAC/RLC configurations, security parameters, actual L1 resource (spreading code or time slot)).<br><br>Due to mobility, handover between radio cells and access routers may be performed. | The location of the terminal is known in the RRA level in the network.<br><br>Information regarding the terminals connections are maintained in the network, i.e. IP BTS. The information contains L2 bearer information (e.g. PDCP and MAC/RLC configurations, security parameters, actual L1 resource if available[1]).<br><br>In order to forward packets to the terminal the network needs to page the terminal from RRA (see some additional discussion in section x).<br><br>In order to start the uplink data transfer the terminal requests (in L2 level) from the IP BTS resources for the connections.<br><br>Due to mobility, change of the radio cells are performed and in case the RRA is crossed the terminal issues a (L2) RRA update. In addition the change of the access router may be performed. |

Fig. 11

Table: Combination of the L2 and IP levels

No CoA,

L2 released

Initial Registration,
Address Autoconfiguration

De-registration

L2 connection moved to
Cell connected state

Valid CoA,

Cell

Valid CoA,

RRA

L2 connection moved to
RRA connected state

Handover

Handover

## Fig. 12

## IP and L2 tracking in 2 levels

# INTERNATIONAL SEARCH REPORT

| | onal Application No |
|---|---|
| | PCT/EP 01/11787 |

## A. CLASSIFICATION OF SUBJECT MATTER
IPC 7    H04L29/06      H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7    H04L   H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | G. DOMMETY:  "Fast Handovers for Mobile IPv6" INTERNET DRAFT, 'Online! 1 January 2001 (2001-01-01), XP002201929 Retrieved from the Internet: <URL:http://www.mc1.hu/micromob/download/draft-ietf-mobileip-fast-mipv6-03.txt> 'retrieved on 2002-06-11! page 8, paragraph 1 page 22, paragraph 1  figure 2 | 1-18 |
| X | US 6 256 300 B1 (AHMED WALID  ET AL) 3 July 2001 (2001-07-03) column 5, line 21 – line 50 column 20, line 46 – line 63  figure 8 | 1,11 |
| | -/-- | |

[X] Further documents are listed in the continuation of box C.          [X] Patent family members are listed in annex.

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| European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016 | Schneider, G |

| C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT | | |
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| Category ° | Citation of document, with indication,where appropriate, of the relevant passages | Relevant to claim No. |
| A | MALINEN: "Mobile IPv6 Regional Registrations" DRAFT-MALINEN-MOBILEIP-REGREG6-00.TXT, 'Online! 14 July 2000 (2000-07-14), XP002201930 Retrieved from the Internet: <URL:people.nokia.net/charliep/txt/regreg6 regreg6.txt> 'retrieved on 2002-06-12! | |
| A | PERKINS: A GENERAL IPV6 HANDOVER DOCUMENT, 'Online! 2 October 2000 (2000-10-02), XP002201931 owner-mipv6-handoff@sunroof.eng.sun.com Retrieved from the Internet: <URL:http://playground.sun.com/pub/mobile-ip/FH-archive/msg00027.html> 'retrieved on 2002-06-11! the whole document | |

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